

Specification No. 990069
17 July 2001

TYPE C3 SPECIFICATION
TO
REPLACE UNIT SUBSTATION, FACILITY 3017

ARNOLD ENGINEERING DEVELOPMENT CENTER
ARNOLD AIR FORCE BASE, TENNESSEE 37389-1332

ATTACHMENT 1

- 1.1 This specification establishes the requirements for the manufacture and acceptance of one 1500/2000 kVA, AA/FA, 13.8kV-480ΔV secondary unit substation, one 500kVA, 480-208Y/120V dry type distribution transformer, two 480V switchboards, and one 208Y/120V switchboard.

2. APPLICABLE DOCUMENTS:

- 2.1 **Government documents.** The following documents form a part of this specification to the extent referenced herein.

2.1.1 **Air Force Federal Acquisition Regulations (AFFARS):**

- a. 5352.223-9000 Elimination of Use of Class I Ozone Depleting Substances (ODS), May 1996.

2.1.2 **Code of Federal Regulations (CFR):**

- a. 29 CFR 1926.1101 Asbestos, 1998.

- 2.2 **Non-Government documents.** The following documents form a part of this specification to the extent referenced herein.

2.2.1 **American National Standards Institute (ANSI) Standards:**

- a. C12.1-95 Electricity Metering, 8th Edition.
- b. C37.13-90 Low-Voltage AC Power Circuit Breakers Used in Enclosures.
- c. C37.16-97 Low-Voltage Power Circuit Breakers and AC Power Circuit Protectors Preferred Ratings, Related Requirements, and Application Recommendations.
- d. C37.17-97 Trip Devices for AC and General Purpose DC Low Voltage Power Circuit Breakers.
- e. C37.20.1-93 Metal-Enclosed Low-Voltage Power Circuit Breaker Switchgear.
- f. C37.20.2-93 Metal-Clad and Station-Type Cubicle Switchgear.
- g. C37.50-95 Switchgear--Low-Voltage AC Power Circuit Breakers Used in Enclosures-Test Procedures.

- h. C39.1-92 Electrical Analog Indicating Instruments.
- i. C57.12.01-98 Dry-Type Distribution and Power Transformers Including Those With Solid-Cast and/or Resin-Encapsulated Windings.
- j. C57.12.28-96 Pad-Mounted Equipment – Enclosure Integrity.
- k. C57.12.50-89 Ventilated Dry-Type Distribution Transformers, 1 to 500kVa Single-Phase and 15 to 500kVA Three-Phase, with High-Voltage 601 to 34,500 Volts, Low-Voltage 120 to 600 Volts.
- l. C57.12.51-89 Ventilated Dry-Type Power Transformers, 501kVA and Larger, Three-Phase, with High-Voltage 601 to 34,500 Volts, Low-Voltage 208Y/120 to 4,160 Volts.
- m. C57.12.55-87 Transformers – Dry-Type Transformers Used in Unit Installations, Including Unit Substations – Conformance Standard.
- n. C57.12.56-93 Thermal Evaluation of Insulation Systems for Ventilated Dry-Type Power and Distribution Transformers.
- o. C57.12.58-91 Guide for Conducting a Transient Voltage Analysis of a Dry-Type Transformer Coil.
- p. C57.12.59-89 Guide for Dry-Type Transformer Through-Fault Current Duration.
- q. C57.12.70-93 Terminal Markings and Connections for Distribution and Power Transformers.
- r. C57.12.91-95 Test Code for Dry-Type Distribution and Power Transformers.
- s. C57.94-87 Installation, Application, Operation, and Maintenance of Dry-Type General Purpose Distribution and Power Transformers.
- t. C57.124-91 Recommended Practice for the Detection of Partial Discharge and the Measurement of Apparent Charge in Dry-Type Transformers.

- u. C57.13-93 Instrument Transformers.

2.2.2 **International Standards Organization (ISO) Standard:**

- a. 9001-94 Quality Systems.

2.2.3 **National Electrical Manufacturers' Association (NEMA) Standards:**

- a. AB 1-93 Molded Case Circuit Breakers and Molded Case Switches.
- b. EI 21.1-93 Instrument Transformers for Revenue Metering 110-kV BIL and Less.
- c. SG 3-93 Power Switching Equipment.
- d. SG 5-95 Power Switchgear Assemblies.
- e. WC 5-96 Thermoplastic-Insulated Wire and Cable for the Transmission and Distribution of Electrical Energy.
- f. WC 7-96 Cross-Linked-Thermosetting-Polyethylene-Insulated Wire and Cable for the Transmission and Distribution of Electrical Energy.

2.2.4 **National Fire Protection Association (NFPA) Standard:**

- a. 70-98 National Electrical Code (NEC).

3. **REQUIREMENTS:**

3.1 **Regulatory.**

3.1.1 **Asbestos products.** Do not use products or materials that contain asbestos on this project except as expressly authorized by the Contracting Officer. If no substitutes for asbestos products are available, and the Contracting Officer approves the use of asbestos products, highlight and detail their exact location on the drawings and identify their location in the field following 29 CFR 1926.1101 guidelines.

3.1.2 **Disallowed products.** Do not use products or materials that contain lead, chromium, mercury, cadmium, barium, or arsenic on this project except as

expressly authorized by the Contracting Officer. If no substitutes for products containing the listed materials are available, and the Contracting Office approves the use of products containing the listed materials, highlight and detail their exact location on the shop drawings.

3.1.3 Elimination of ODS chemicals. The use of Class I ozone depleting substances (ODS) is prohibited. Reference text of AFFARS clause 5352.223-9000 (May 1996).

3.1.4 Year 2000-compliant technology. All information technology items shall be Year 2000 (Y2K) compliant. Year 2000 compliant means information technology that accurately processes date/time data (including, but not limited to, calculating, comparing, and sequencing) from, into, and between the twentieth and twenty-first centuries, and the years 1999 and 2000 and leap year calculation. Furthermore, Year 2000-compliant technology shall accurately process date/time data if the other information technology properly exchanges date/time data with it.

3.1.5 ISO 9001-compliant technology. All electronic components shall be ISO 9001 compliant.

3.2 Item definition.

3.2.1 One 13,800-480 Δ V, 1500/2000kVA outdoor secondary unit substation, with forced-air cooling.

3.2.2 One indoor general purpose dry-type transformer rated 500kVA, 480-208Y/120V.

3.2.3 One switchboard rated 480V, 2000 amperes (A) continuous.

3.2.4 One switchboard rated 480V, 800 amperes continuous.

3.2.5 One switchboard rated 208Y/120V, 2000A continuous.

3.3 Characteristics.

3.3.1 Secondary unit substation. Furnish an outdoor, metal-enclosed, encapsulated dry-type, unit substation, rated 13,800-480 Δ V, 3-phase, 3-wire, 60-Hertz (Hz), delta-to-delta connected, 1500kVA self-cooled, 2000kVA forced air cooled, with incoming, transforming, and outgoing non walk-in sections arranged left to right, as indicated on Sketch SK-ALC-US Elevation, Appendix 7.2. Mount the three-phase conductors on insulating supports and spacers inside a common, non-ventilated, dust-tight enclosure

fabricated of heavy gauge sheet steel not less than No. 12 gauge. Covers for enclosure openings shall be heavy gauge sheet steel not less than No. 12 gauge. Design the enclosure such that the installation and alignment of all bus sections and completion of all conductor field joints can be made before the enclosure is completely closed. Finish and paint metal surfaces of the secondary unit substation in accordance with paragraph 6.1.5 of ANSI C37.20.2, except that all outside surfaces shall be given not less than two coats of quick air-drying lacquer or synthetic enamel. ANSI No. 70 Sky Gray with gloss finish is preferred, but ANSI No. 49 and 61 will be acceptable as an alternate. Provide 120V space heaters in each section.

3.3.1.1 Primary switchgear. Furnish a dead-front, metal-enclosed, free-standing structure, with bottom entry containing the primary switchgear buses with the following features:

- a. The switch shall have a fault closing and momentary rating of 40,000A root mean square (RMS) asymmetrical, rated short-time current (2 seconds) of 25,000A RMS symmetrical with a continuous current rating of 600A.
- b. Bus rated at 15-kV design voltage and 95-kV basic impulse level (BIL).
- c. Bus bracing to withstand 40,000A fault current.
- d. Switchgear arrangement to permit connecting the unit substation to one incoming 13.8-kV feeder rated 15-kV, 600-A, and lockable in any position. Furnish a fused load-break air switch as part of the switchgear to interrupt power to the unit substation. Primary switchgear arrangement is shown on the one-line diagram, Sketch SK-ALC-One Line, Appendix 7.1.
- e. The switch shall be manually operable from the front of the unit, and the switch mechanism shall provide quick closing and opening, independent of the handle speed. Spacing between phases shall be a minimum of 5-inches. The main blades shall be made of electrolytically pure cold rolled copper. All contact points shall be heavily silver plated on blades as well as the hinge and jaw castings. These contacts will each be one piece castings to provide maximum heat dissipation and continuous current transfer. Install an inspection window barrier such that all easily reached energized parts are covered when the switch door is open. Install an inspection window for visual inspection of the

switch blades and fuse trip indicators with the compartment door closed.

- f. Furnish 100A continuous current, 50 kilo-ampere (kA) interrupting current, high-voltage, type E fuses and fuse holders for each circuit phase on the load side of the high voltage switch in the high voltage switch compartment, and mount three spare 100A fuses inside the enclosure door.
- g. Furnish the high voltage switch with three distribution-type Metal-Oxide-Varistor surge arresters rated 18kV RMS.
- h. Furnish insulating barriers between phases and between outer phases and the enclosure. Furnish one 2-hole copper pad per phase, mounted on porcelain insulators for attaching compression-type cable terminals with sufficient vertical space for an electrical stress-relief termination system. Provide copper bus and use only porcelain bus supports. Silver plate all joints with a minimum thickness of 2 mils.
- i. Furnish universal frame enclosure using die-formed, welded, and bolted members. Enclosure covers and doors shall be fabricated of steel, not less than No. 12-gauge. The enclosure shall have rear-hinged, padlockable doors with three-point latches to facilitate installation and maintenance of cables and bus. The front access door shall be interlocked with the switch so that the door cannot be opened until the switch is in the open position, and the switch cannot be closed until the door is closed. The enclosure shall be suitable for outdoor service. Furnish a nameplate on the front door of the enclosure identifying the switch characteristics. Make the high-voltage switch section ready for field assembly without user modifications, and furnish complete assembly instructions. Make provisions for floor entry of incoming 13.8kV feeder.
- j. Furnish load-side buses that match the transformer primary buses such that the switch-to-transformer connection is ready for field assembly without any user modifications. Manufacture the switchgear in accordance with NEMA SG 5.
- k. Furnish 120V space heaters in this compartment. Furnish adequate space heaters to prevent the formation of condensation within the compartment while operating in the

unit substation room environment. Power to heaters will be supplied by the Government.

3.3.1.2 **Substation transformer.** The transformer shall conform to C57.12.01, C57.12.51, and C57.12.94. The transformer ratings are: 1500kVA self-cooled, 2000kVA forced air cooled, 3-phase, 3-wire, 60-Hz; 13,800V delta primary voltage, 60kV basic insulation level (BIL); 480ΔV secondary voltage, 10kV BIL. The transformer shall have the following characteristics:

- a. Substation type with side-wall mounted primary and secondary terminations for close coupling to high and low voltage switchgear sections.
- b. Transformer shall be cast-coil, dry-type construction, mounted in a suitable ventilated outdoor enclosure.
- c. Standard taps (full capacity) in the high-voltage windings in addition to normal voltage: one at 5 percent above normal, one at 2.5 percent above normal, one at 2.5 percent below normal, and one at 5 percent below normal.
- d. The average temperature rise of the transformer windings shall not exceed 80°C when the transformer is operated at full nameplate rating. The transformers shall be capable of carrying 133% of nameplate kVA rating in a 40°C maximum, 30°C average ambient as defined by ANSI C57.12.01. The transformer shall have copper windings and a Class H 220° C insulation system. The impedance of the transformer shall be 5.75 percent nominal.
- e. Both high and low voltage windings shall be of copper conductors. High and low voltage windings shall be separately cast as one rigid tubular coil, arranged coaxially. Each cast coil shall be fully reinforced with glass cloth, and cast under vacuum to provide complete, void-free resin impregnation throughout the entire insulation system. Reinforcement with suspended particulate matter (filled-resin) is not acceptable. The coil supports shall maintain constant pressure during thermal expansion and contraction of the coils. There shall be no mechanical connection between the high and low voltage coils.
- f. The windings must not absorb moisture, and shall be suitable for storage and operation in adverse environments, including

prolonged storage in 100% humidity at temperatures from -40°C to +40°C and shall be capable of immediately being switched on after such storage without pre-drying.

- g. The transformer core shall be constructed of high grade, grain-oriented silicon steel laminations, with high magnetic permeability. Magnetic flux density is to be kept well below the saturation point. The core shall be cruciform shaped, with mitered joints to keep core losses, excitation current and noise level at a minimum. The outside surfaces of the core shall be protected against corrosion by painting with a suitable coating after assembly. Core dipping is not acceptable.
- h. Low voltage bus shall be silver plated copper throughout.
- i. Furnish the transformer with an outdoor, ventilated, heavy gauge sheet-steel enclosure not less than No. 12 gauge. All ventilation openings shall be in accordance with NEMA and NEC standards for ventilated enclosures. Ventilation openings for outgoing air shall be through side panel louvers. Incoming air flow shall be through the base for optimum air flow to the transformer. The enclosure shall have rear-hinged, padlockable doors with three-point latches to facilitate installation and maintenance of cables and bus. Furnish suitable, removable lifting eyes or other approved means to permit lifting the enclosure alone and also lifting the complete transformer with a crane. The base shall be constructed to permit rolling or skidding in any direction, and shall be equipped with jacking pads designed to be flush with the transformer enclosure. Furnish internal braces and stiffeners, and coat the interior of the enclosure, if required, with sound-absorbing material such that, at rated load, the audible sound level of the enclosed transformer does not exceed 69 decibels (db) measured at a distance of three feet.
- j. Provide forced air equipment so that the continuous forced air cooled capacity of the transformer will be at least 133-1/3 percent of the self cooled rating without exceeding the allowable temperature rise. Provide forced air delivery with low noise level. Fan motors shall have anti-friction bearings with an L10 rating of 40,000 hours minimum operating life. Dynamically balance the fan motors and the blades. The fan

motors shall be rated 208-volts, 3-phase, 60Hz, alternating current (ac).

- k. Furnish and install all necessary overcurrent devices and control equipment for the fan motors in a weatherproof steel cabinet mounted to the unit substation. The fans shall be 208V, 3-phase, and powered from an external source supplied by the government. The control voltage for the fans shall be 120V, powered from an external source supplied by the government. Provide fully automatic control equipment designed to start and stop the fan motors as the transformer winding temperature requires. Provide alarm contacts for loss of control voltage and loss of fan power. The loss of fan power shall indicate a condition that the fan contactor has closed but the fans are not operating.
- l. Furnish three-phase winding temperature indicating equipment with three adjustable set point circuit closing contacts and a resettable draghand to capture the hottest temperature experienced. The first contact closure shall be used to automatically start the cooling equipment when operating at more than 100 percent of the self cooled rating. A second contact closure shall be for an alarm to indicate that the temperature has exceeded 133 percent of the self-cooled rating. A third contact closure shall be for an alarm to indicate that the maximum safe winding temperature for safe operation has been reached.
- m. Furnish copper-faced steel ground pads to the enclosure frame for grounding provisions, lifting hooks for complete unit lifting, high-voltage tap access panel for making the mechanical connection to the high-voltage load-interrupter switch, low-voltage tap access panel for making bus connections to the switchgear transition section, and a stainless steel nameplate showing transformer ratings, impedance, and connections.
- n. Furnish porcelain supports for the primary bus and silver plated bus joints with a minimum 2-mil thickness. Use silicon bronze bolts for all bolted connections.
- o. Furnish 120V space heaters in this section. Power to the heaters will be supplied by the customer.

3.3.1.3 Secondary distribution switchgear. The switchgear assembly shall be rated 480ΔV, 3-phase, 3-wire, 3000 amperes continuous. The momentary and the short time (0.5 second) short circuit rating shall be 65,000A asymmetrical and a 30-cycle short time rating equal to the interrupting rating. The enclosure shall be non walk-in suitable for outdoor service with bottom entry. The switchgear shall have the following features:

- a. Stationary structure assembly suitable for 600-V maximum service and able to successfully withstand a dielectric test for that voltage class in accordance with ANSI standards. The switchgear shall be designed, manufactured, and tested in accordance with the latest applicable standards of ANSI and NEMA.
- b. Furnish metal-enclosed switchgear conforming to ANSI C37.20.1 consisting of a incoming main lugs only, and individually mounted, draw-out, power-type feeder circuit breakers. Furnish a full-size copper ground bus, extending the length of the switchgear. Devices shall be front removable with load connections rear accessible.
- c. Furnish three ground detection lamps in the metering compartment.
- d. Each steel unit forming a part of the stationary assembly shall be self-contained. The main secondary circuit breaker compartment shall be equipped with primary and secondary contacts, and instrument current transformers (CTs) as required by this specification. The enclosure shall have rear-hinged, padlockable doors with three-point latches to facilitate installation and maintenance of cables and bus. The compartment shall have hinged interior doors with a single latch.
- e. Grounding of the breaker frame to the steel frame shall be maintained throughout the travel of the draw out mechanism.

3.3.1.4 Buses and connections. In each bus section, furnish buses having a continuous current-carrying capacity of not less than 125% the forced air ampacity rating of the transformer. The buses and connections shall have the following features:

- a. Mechanical and thermal capacities coordinated with the interrupting rating of the power-supply circuit breakers. The

momentary and the short time (0.5 second) short circuit rating shall be 65,000A asymmetrical.

- b. Phase conductor conforming to NEMA WC 5, made of bare hard-drawn copper, which, when assembled, can withstand a dry one-minute power frequency withstand dielectric test of 2.2 kV between each conductor and the other conductors, and between all conductors connected and the grounded metal housing in accordance with ANSI C37.20.1.
- c. Phasing within the equipment housing shall be A-B-C from left to right when facing the front of the equipment, A-B-C from top to bottom, and A-B-C from front to back. All buses, after assembly, shall withstand the dielectric test required in paragraph 4.1.3.
- d. Sufficient bolts to ensure low-resistance contacts. Braze, pressure weld, or bolt all shop splices and tap connections. Bolt all splices for field assembly. Where bolted connections are required, use silver-plated contact surfaces.
- e. Buses that match the transformer primary and secondary buses such that the switchgear-to-transformer connections are ready for field assembly without any user modifications. Mount the buses on insulating supports of wet-process porcelain. Furnish bare bus bar to all primary connections, including the power connections to the line side of the circuit breakers.
- f. Provide for floor entry of existing power and control cables to switchgear. Furnish sufficient space for all cables. Furnish adequate means to support the cables between the conductor terminating points and where they enter or leave the switchgear.

3.3.1.5 **Power circuit breakers.** Furnish breakers with frame and trip ratings as shown on attached sketch SK-ALC-One Line, Appendix 7.1, conforming to the requirements of NEMA SG 3, ANSI C37.13, C37.16, and C37.17. Circuit breakers shall be 100-percent rated and include the following:

- a. Current sensors and rating plugs to obtain the trip rating shown on sketch SK-ALC-One Line Appendix 7.1. Final trip settings will be set using the solid state trip units specified in

paragraph 3.3.1.7. The operating mechanism shall be mechanically trip-free.

- b. Integrally mounted, spring-charged motor mechanism that includes open and close push buttons. Furnish an emergency spring charging handle, operable through the breaker faceplate. Each mechanism shall operate a position indicator which shall give positive indication of the contact position whether open or closed and operate an indicator showing spring charged or discharged on the breaker faceplate, with provision for padlocking the manual charging handle, locking the breaker in the open position, and locking the drawout mechanism.
- c. Drawout circuit breaker with three defined positions—connected, test, and disconnected—all with the enclosure door closed, and equipped with an interlock that shall prevent connecting or disconnecting the breaker from the bus stabs unless the breaker is in the tripped (open) position. Interlocks shall also discharge the stored energy springs when the breaker is fully withdrawn. Circuit breaker power drawout contacts shall be silver plated. The drawout mechanism shall hold the breakers rigidly in the fully connected, test, and fully disconnected positions with the door closed.
- d. Furnish a control power isolating switch to interrupt power to the spring-charging motor on the breaker faceplate.
- e. Portable plug-in test device to test and calibrate the time and current characteristics and trip circuit.
- f. Furnish a portable breaker lifting device.
- g. Functional components for the main circuit breaker in accordance with NEMA SG3, including means for manual emergency tripping and for manual closing for maintenance operation. An operation counter shall be furnished on the breaker.

3.3.1.6 **Secondary distribution assembly.** Circuit breakers and the switchgear shall be fully rated. The momentary and the short time (0.5 second) short circuit rating shall be 42,000A asymmetrical. Minimum frame rating of the breakers shall be as shown on attached sketch SK-ALC-One Line, Appendix 7.1.

- a. Assembly shall consist of switchgear with individual mounted 100% rated power circuit breakers. Equip the switchgear for 3-phase, 3-wire. All circuit breakers shall be capable of accepting cable connections and rear accessible.
- b. Furnish 120V space heaters in this section. Power to heaters will be supplied by the customer.
- c. Furnish a breaker racking handle with permanently mounted storage location inside the door.

3.3.1.7 **Solid state tripping devices.** Furnish tripping devices with the following features for each breaker:

- a. A solid-state trip device having the following adjustments: long-time rating between 50 percent and 100 percent of the trip rating in multiple increments, long-time delay between 2.4 and 20 seconds at six times trip rating in multiple increments, short-time pickup between 2 and 9 times trip rating in multiple increments, short-time delay between 0.1 and 0.4 second at 12 times trip rating in multiple increments, instantaneous pickup between 3 and 12 at trip rating in multiple increments with the ability to be disabled. Adjustments shall be continuous, with each adjustment independent of all others.
- b. True RMS current sensing for long-time characteristics.
- c. Indication of mode of trip following a trip operation.

3.3.1.8 **Instrument transformers.** Furnish current transformers (CT) and potential transformers (PT) with the following features:

- a. The CTs shall be rated not less than 600-V, appropriately rated for the application.
- b. The PTs shall conform to ANSI C37.20.2 0.3-meter accuracy.
- c. Mount three CTs on the line side of the bus. Mount one 3000:5 CT with multi-ratio taps on each phase. Furnish two PTs with 120-V secondary voltage, 480-V primary voltage, current-limiting primary fuses, mounted within the instrument compartment. Furnish PK test shorting block inside the instrument compartment for CT and PT termination. All PTs

and CTs furnished under this section shall conform to NEMA EI21.1 and ANSI C57.13 and have the ratios indicated on the engineering drawings.

3.3.1.9 Electric meter. Furnish electric metering conforming to ANSI C12.1 with the following features:

- a. Auxiliary voltage input range shall be 0 to 1 V (ac or direct current-(dc)).
- b. Auxiliary analog current output 0-20 milli-amperes (mA) proportional to any measured parameter.
- c. Accuracies (percent full scale) of voltage and current shall be 0.2 percent. Accuracies (percent full scale) of power, energy, and demand shall be 0.4 percent.
- d. High-speed waveform capture function and an independent waveform recording function for any of the eight voltage or current inputs: minimum 64 samples-per-cycle. The meter shall also provide waveform recording of all input signals before, during, and after a disturbance for a minimum of 36 cycles.
- e. The electric meter shall be a panel-mountable microprocessor-based digital instrumentation package for 3-phase power system.
- f. Configurable for 4-wire wye, 3-wire delta, and single-phase power distribution systems. The meter shall have three-phase voltage and three-phase current inputs with an additional current input. An auxiliary voltage input shall be furnished to measure an external variable such as transformer temperature or battery voltage. Four digital inputs shall be furnished to monitor breaker status and any other external dry contact, which can be used as pulse counters to measure device cycles or running hours.
- g. Three Form C control relays that can be automatically controlled by an extensive user-programmable setpoint system or manually operated by commands made via the communications port. Relays shall perform operations ranging from simple alarm activations to fully automated demand, power factor, or load control. Relays shall operate in a latched or pulsed mode, and can also be programmed to provide kilo-Watthour (kWh) (import/export), kilovolt-ampere-

reactive-hour (kVARH) (import/export), or kilovolt-ampere-hour (kVAH) output pulsing.

- h. High accuracy, real-time, three-phase measured parameters, and status parameters. Real-time measurements include: Volts, Amps, Neutral/Ground Current, kilo-Watt (kW), kVA, kilovolt-ampere-reactive (kVAR), Power Factor (PF), and Frequency.
- i. The meter shall be capable of power quality analysis for total and individual harmonic distortion values for all voltage and current inputs to at least the thirty-first harmonic. The meter shall have inboard logging with non-volatile memory. It shall have optically isolated and transient protected ports for RS-485 and RS-232C communications.

3.3.1.10 **Control wiring.** Use stranded copper switchboard wire with 600-V insulation for control wiring, type SIS. The wiring shall have the following features:

- a. Install all wiring in accordance with the NEC and NEMA standards. Control wiring conductors shall be not less than No. 12 American Wire Gage (AWG), except for current transformer secondary leads, which shall be not less than No. 10 AWG. Power wiring for 480-V circuits shall be no smaller than No. 12 AWG.
- b. Wiring, where not installed in channels or ducts, shall be formed into compact bundles, suitably bound together, and properly supported. Bindings and supports shall not cause damage to the insulation. Run groups of exposed wiring horizontally or vertically with short-radius, right-angle bends. Use heavy-gage, rust-proof material with rust-resistant finish for wiring supports. Do not splice wiring. Make all connections at terminal studs or terminal blocks with insulated ring-tongue-indented terminals for current transformer connections and insulated fork-tongue terminals for all others. Shield control wiring within high-voltage compartments in a protective metal covering. Use hinge wire between stationary panels and swinging panels or swinging door, and form in vertical wire loops to provide rotation around the longitudinal axis of the conductors.
- c. Use terminal blocks to terminate all external cables. Identify each internal interconnecting wire at each end with a plastic

sleeve-type or shrink tubing stamped with the complete destination address. Tape-type wire markers are not acceptable. Wire markings shall match the manufacturer's wiring and interconnection drawings.

3.3.1.11 Terminal blocks. Each terminal block shall be rated not less than 600 V with the following features:

- a. Molded, fabricated-type terminal blocks with barriers for control wiring. Furnish the terminals with removable binding, fillister, or washer-head screws, or studs with contact and locking nuts. Use terminals no smaller than No. 10 with sufficient length and space to connect at least two indented terminal connectors for No. 12/10 AWG conductors to each terminal.
- b. Short-circuiting terminal blocks at the first terminal point for all CT secondary leads with provisions for shorting together all leads from each CT without first opening any circuit. The terminal arrangement shall be subject to approval by the Contracting Officer.
- c. Not less than 10 percent spare terminals on each block or group of blocks. Furnish white or other light-colored plastic marking strips, fastened by screws to each terminal block for control wire designations. Show the manufacturer's wire number for each connected terminal on the marking strips with permanent marking fluid. Furnish reversible marking strips to permit marking both sides, or furnish two marking strips with each block, to accommodate the two sets of wire numbers.
- d. Terminal blocks rated not less than 600 V and of adequate capacity for the conductors of power circuits except those supplied from the circuit breakers. Use conducting parts between connected terminals with adequate contact surface and cross-section to operate without overheating. Furnish each connected terminal with the circuit designation or wire number marked on or near the terminal in permanent contrasting color.
- e. Terminal blocks with integral barriers for secondary circuits.

- f. Terminal blocks with accessibility through a removable cover if installed at the rear of the unit.

3.3.1.12 **Grounding.** Ground in accordance with paragraph 6.1.2 of ANSI C37.20.1-1987. Furnish a full-length interior ground bus of copper bar to which the housing, framework, cable supports, bus supports, and non-current-carrying metallic parts of all equipment and conduits are grounded. Do not solder ground lead connections.

3.3.1.13 **Control switches.** Furnish control switches suitable for operation on 600-V ac or 250-V dc circuits with the following features:

- a. Switches capable of satisfactorily withstanding a life test of at least 10,000 operations with rated current flowing in the switch contacts.
- b. Switches with the capability of continuously carrying 20 A without exceeding a temperature rise of 30°C.
- c. Single-break inductive switches with load-interrupting ratings of not less than 1.5-A for 125-V dc or 10-A for 115-V ac.
- d. Control switches with rotary switchboard-type handles on the front and the operating contacts on the rear of the panels.
- e. Switches with ample contact stages to perform the functions of the control system.
- f. Contacts with self-aligning and wiping-action capability.
- g. A positive means of maintaining high pressure on closed contacts. Do not use compression springs or pivotal joints to carry current.
- h. Readily removable covers or plates on the switches for inspection of contacts.
- i. Control switches with an escutcheon clearly marked to show each position. Engrave the switch identifications on the escutcheon plates or on separate nameplates. The escutcheon and nameplate markings are subject to approval by the Contracting Officer.

- j. Instrument and meter transfer switches of the maintained contact type with the required number of positions and with round-notched or knurled handles.
- k. Ammeter switches that make before break so that the CT secondary circuits are never opened.
- l. Oval-handle switches for voltage selection.

3.3.1.14 **Indicating lamp assemblies.** Furnish switchboard indicating lamp assemblies, insulated for 125-V service, with appropriately colored caps and integrally mounted resistors for nominal 125-V service, 140-V maximum with the following features:

- a. Furnish long-life, low-wattage lamps, replaceable from the front of the panels, and any special tools required for lamp replacement.
- b. Furnish color caps made of transparent or translucent material, which will not soften from the heat of the lamps.
- c. Furnish red caps to indicate closed, green caps to indicate open and white caps to indicate clear.

3.3.1.15 **Indicating instruments.** Potential coils designed for continuous operation at 150V and instrument current coils capable of withstanding 40 times rated current for 2 seconds with the following features:

- a. Back-connected, semi-flush mounting with white dials, circular scales, black scale markings, and black, tapered anti-parallax pointers. Furnish dust-tight instrument cases, shadow-proof covers, and anti-glare windows. Furnish taut-band suspension where this design is available. Furnish zero-adjusting capability from the instrument front without removal of covers for instruments with spring control. Furnish ac instruments designed for use on 60-Hz circuits and for operation from 120-V secondaries of PTs and 5-A secondaries of CTs.
- b. Instrument identification legends neatly printed on the dials or on separate legend plates inside the cases. Furnish instruments with 4-1/2-inch rectangular, 250-degree scale angle and zero-left scales. Furnish ac voltmeters with expanded-type scales.

3.3.1.16 **Accessories.** Furnish a complete set of handling and testing accessories needed to remove, replace, test, and maintain the drawout type air circuit breakers. The accessories include, but are not limited to, the following:

- a. Special tools for indicating lamp replacement.
- b. One portable test set from the same manufacturer as the static trip devices to check the operation of the static trip devices without the need for primary current injection.
- c. Three 1-quart containers of paint for the outside finish.
- d. Three tubes of conductive grease for breaker stabs.
- e. Digital test kit for digital trip units.

3.3.2 General purpose distribution transformer.

- 3.3.2.1 All insulating materials are to exceed NEMA ST20 standards and be rated for 220° C UL component recognized insulation system.
- 3.3.2.2 Transformer shall be 80° C temperature rise above 40° C ambient. 80° C rise transformers shall be capable of carrying a continuous 30% overload without exceeding a 150° C rise in a 40° C ambient. Transformer shall have a minimum of 4 - 2.5% full capacity primary taps. 2 above and 2 below the nominal voltage tap.
- 3.3.2.3 The maximum temperature of the top of the enclosure shall not exceed 35° C rise above a 40° C ambient.
- 3.3.2.4 The transformer shall be rated 500kVA, 480-208Y/120V, 3-phase, 60-hz, 80° C rise.
- 3.3.2.5 Transformer coils shall be copper, utilize continuous wound construction, and shall be impregnated with nonhygroscopic, thermosetting varnish.
- 3.3.2.6 All cores shall be constructed with low hysteresis and eddy current losses. Magnetic flux densities are to be kept well below the saturation point to prevent core overheating. Core shall be clamped utilizing insulated bolts through the core laminations to provide proper pressure throughout the length of the core. The completed core and coil shall be bolted to the base of the enclosure but isolated by means of rubber vibration-absorbing mounts. There shall be no metal-to-metal contact between the core and coil and the enclosure except for a flexible safety ground strap. Sound isolation systems requiring the complete removal of all fastening devices will not be acceptable.
- 3.3.2.7 The core of the transformer shall be visibly grounded to the enclosure by means of a flexible grounding conductor sized in accordance with applicable UL and NEC standards.
- 3.3.2.8 The transformer enclosures shall be ventilated and be fabricated of heavy gauge, sheet steel construction. The entire enclosure shall be finished utilizing a continuous process consisting of degreasing, cleaning and phosphatizing, followed by electrostatic deposition of polymer polyester powder coating and baking cycle to provide uniform coating of all edges and surfaces. The coating

shall be UL recognized for outdoor use. The coating color shall be ANSI No. 49, 61, or 70.

3.3.2.9 Sound levels shall be warranted by the manufacturer not to exceed the following: 301 to 500 kVA - 60 dB

3.3.2.10 Provide weathershields.

3.3.3 480V switchboard with power circuit breakers

3.3.3.1 **Short circuit current rating:** Switchboard shall be rated with a minimum short circuit current rating of 65,000 RMS symmetrical amperes , momentary and short time, at 480 VAC maximum. See attached sketch SK-ALC-480V SWBD #1, Appendix 7.4 for arrangement.

3.3.3.2 **Future Provisions:** All unused spaces provided, unless otherwise specified, shall be fully equipped for future devices, including all appropriate connectors and mounting hardware.

3.3.3.3 **Enclosure:** NEMA 1 - General Purpose with drip hood.

3.3.3.4 Sections shall be aligned front and rear.

3.3.3.5 Switchboard height shall be no more than 92-inches including floor sills and excluding lifting members and pull boxes.

3.3.3.6 The switchboard shall be of deadfront construction.

3.3.3.7 The switchboard frame shall be of formed steel rigidly bolted together to support all cover plates, bussing and component devices during shipment and installation.

3.3.3.8 Steel base channels shall be bolted to the frame to rigidly support the entire shipping section for moving on rollers and floor mounting.

3.3.3.9 Each switchboard section shall have an open bottom and an individually removable top plate for installation and termination of conduit.

3.3.3.10 The switchboard enclosure shall be painted on all exterior surfaces. The paint finish shall be ANSI #49, 61, or 70, applied by the electro-deposition process over an iron phosphate pre-treatment.

- 3.3.3.11 All front covers shall be screw removable with a single tool and all doors shall be hinged with removable hinge pins.
- 3.3.3.12 Top and bottom conduit areas shall be clearly indicated on shop drawings.
- 3.3.3.13 **Nameplates:** Provide 1-inch high by 3-inches wide engraved laminated (Gravoply) nameplates for each device. Furnish black letters on a white background for all voltages.
- 3.3.3.14 **Bus composition:** Plated copper rated 2000A. Plating shall be applied continuously to all bus work. The switchboard bussing shall be of sufficient cross-sectional area to meet UL Standard 891 temperature rise requirements. The phase bus shall have an ampacity as shown in the plans. Tapered bus is not acceptable. Full provisions for the addition of future sections shall be provided. Bussing shall include all necessary hardware to accommodate splicing for future additions.
- 3.3.3.15 **Bus connections:** Bolted with Grade 5 bolts and conical spring washers.
- 3.3.3.16 **Ground bus:** Sized per NFPA70 and UL 891 Tables 25.1 and 25.2 and shall extend the entire length of the switchboard. Provisions for the addition of future sections shall be provided.
- 3.3.3.17 **Accessibility:** Accessible from the front and rear of the switchboard.
 - a. Incoming main section devices
 - 1) Main lug only, rated 2000A.
 - 2) Incoming conductors shall terminate at lug landing pads rated at 2000A.
 - b. Distribution section devices. Furnish power circuit breakers with frame and trip ratings as shown on attached sketch SK-ALC-One Line, Appendix 7.1, conforming to the requirements of NEMA SG 3, ANSI C37.13, C37.16, and C37.17. Circuit breakers shall be 100-percent rated and include the following:
 - 1) Manually operated low-voltage-power, 100 (%) rated, 3-

pole, dead-front, drawout-type 600V alternating current (ac) circuit breakers

- 2) Current sensors and rating plugs to obtain the trip rating shown on sketch SK-ALC-One Line, Appendix 7.1. Final trip settings will be set using the solid state trip units specified in paragraph 3.3.1.7. The operating mechanism shall be mechanically trip-free.
- 3) Integrally mounted, spring-charged motor mechanism that includes open and close push buttons. Furnish an emergency spring charging handle, operable through the breaker faceplate. Each mechanism shall operate a position indicator which shall give positive indication of the contact position whether open or closed and operate an indicator showing spring charged or discharged on the breaker faceplate, with provision for padlocking the manual charging handle, locking the breaker in the open position, and locking the drawout mechanism.
- 4) Drawout circuit breaker with three defined positions—connected, test, and disconnected—all with the enclosure door closed, and equipped with an interlock that shall prevent connecting or disconnecting the breaker from the bus stabs unless the breaker is in the tripped (open) position. Interlocks shall also discharge the stored energy springs when the breaker is fully withdrawn. Circuit breaker power drawout contacts shall be silver plated. The drawout mechanism shall hold the breakers rigidly in the fully connected, test, and fully disconnected positions with the door closed.
- 5) Faceplate-mounted control buttons, indicator interlocks, and other operating controls that are accessible without opening the enclosure door. Furnish a control power isolating switch to interrupt power to the spring-charging motor on the breaker faceplate.
- 6) Portable plug-in test device to test and calibrate the time and current characteristics and trip circuit.
- 7) Functional components for the circuit breakers in accordance with NEMA SG3, including means for manual emergency tripping and for manual closing for maintenance operation. An operation counter shall be

furnished on the breaker.

3.3.4 **480V switchboard with molded case circuit breakers**

- 3.3.4.1 **Short circuit current rating:** Switchboard shall be rated with a minimum short circuit current rating of 65,000 RMS symmetrical amperes at 480 VAC maximum.
- 3.3.4.2 **Future provisions:** All unused spaces provided, unless otherwise specified, shall be fully equipped for future devices, including all appropriate connectors and mounting hardware.
- 3.3.4.3 **Enclosure:** NEMA 1 - General purpose with drip hood.
- 3.3.4.4 Sections shall be aligned front and rear.
- 3.3.4.5 Switchboard height shall be no more than 92-inches including floor sills and excluding lifting members and pull boxes. See attached sketch SK-ALC-480V SWBD #2, Appendix 7.5 for arrangement.
- 3.3.4.6 The switchboard shall be of deadfront construction.
- 3.3.4.7 The switchboard frame shall be of formed steel rigidly bolted together to support all cover plates, bussing and component devices during shipment and installation.
- 3.3.4.8 Steel base channels shall be bolted to the frame to rigidly support the entire shipping section for moving on rollers and floor mounting.
- 3.3.4.9 Each switchboard section shall have an open bottom and an individually removable top plate for installation and termination of conduit.
- 3.3.4.10 The switchboard enclosure shall be painted on all exterior surfaces. The paint finish shall be ANSI #49, 61, or 70, applied by the electro-deposition process over an iron phosphate pre-treatment.
- 3.3.4.11 All front covers shall be screw removable with a single tool and all doors shall be hinged with removable hinge pins.
- 3.3.4.12 Top and bottom conduit areas shall be clearly indicated on shop drawings.

- 3.3.4.13 **Nameplates:** Provide 1-inch high by 3-inches wide engraved laminated (Gravoply) nameplates for each device. Furnish black letters on a white background for all voltages.
- 3.3.4.14 **Bus composition:** Plated copper rated 800A. Plating shall be applied continuously to all bus work. The switchboard bussing shall be of sufficient cross-sectional area to meet UL Standard 891 temperature rise requirements. The phase bus shall have an ampacity as shown in the plans. Tapered bus is not acceptable. Full provisions for the addition of future sections shall be provided. Bussing shall include all necessary hardware to accommodate splicing for future additions.
- 3.3.4.15 **Bus connections:** Bolted with Grade 5 bolts and conical spring washers.
- 3.3.4.16 **Ground bus:** Sized per NFPA70 and UL 891 Tables 25.1 and 25.2 and shall extend the entire length of the switchboard. Provisions for the addition of future sections shall be provided.
- 3.3.4.17 **Accessibility:** Accessible from the front and rear of the switchboard.
- a. Incoming main section devices
 - 1) Main lug only, rated 800A.
 - 2) Incoming conductors shall terminate at lug landing pads rated at 800A.
 - b. Distribution section devices. Furnish molded case circuit breakers with frame and trip ratings as shown on attached sketch SK-ALC-One Line, Appendix 7.1, conforming to the requirements of NEMA SG 3, and include the following:
 - 1) Group mounted, 80% rated, thermal magnetic, molded case circuit breakers.
 - 2) Branch circuit breakers shall be group mounted bolt-on type.
 - 3) The interior shall have three flat bus bars stacked and aligned vertically with porcelain insulators laminated between phases. The porcelain insulators shall support and provide phase isolation to the entire length of bus

3.3.5 208/120V Switchboard

- 3.3.5.1 **Short circuit current rating:** Switchboard shall be rated with a minimum short circuit current rating of 65,000 RMS symmetrical amperes at 240 VAC maximum. See attached sketch SK-ALC-208V SWBD, Appendix 7.6 for arrangement.
- 3.3.5.2 **Future provisions:** All unused spaces provided, unless otherwise specified, shall be fully equipped for future devices, including all appropriate connectors and mounting hardware.
- 3.3.5.3 **Enclosure:** NEMA 1 - General Purpose with drip hood.
- 3.3.5.4 Sections shall be aligned front and rear.
- 3.3.5.5 Switchboard height shall be no more than 92-inches including floor sills and excluding lifting members and pull boxes.
- 3.3.5.6 The switchboard shall be of deadfront construction.
- 3.3.5.7 The switchboard frame shall be of formed steel rigidly bolted together to support all cover plates, bussing and component devices during shipment and installation.
- 3.3.5.8 Steel base channels shall be bolted to the frame to rigidly support the entire shipping section for moving on rollers and floor mounting.
- 3.3.5.9 Each switchboard section shall have an open bottom and an individually removable top plate for installation and termination of conduit.
- 3.3.5.10 The switchboard enclosure shall be painted on all exterior surfaces. The paint finish shall be ANSI #49, 61, or 70, applied by the electro-deposition process over an iron phosphate pre-treatment.
- 3.3.5.11 All front covers shall be screw removable with a single tool and all doors shall be hinged with removable hinge pins.
- 3.3.5.12 Top and bottom conduit areas shall be clearly indicated on shop drawings.

- 3.3.5.13 **Nameplates:** Provide 1-inch high by 3-inches wide engraved laminated (Gravoply) nameplates for each device. Furnish black letters on a white background for all voltages.
- 3.3.5.14 **Bus composition:** Plated copper rated 2000A. Plating shall be applied continuously to all bus work. The switchboard bussing shall be of sufficient cross-sectional area to meet UL Standard 891 temperature rise requirements. The phase bus shall have an ampacity as shown in the plans. Tapered bus is not acceptable. Full provisions for the addition of future sections shall be provided. Bussing shall include all necessary hardware to accommodate splicing for future additions.
- 3.3.5.15 **Bus connections:** Bolted with Grade 5 bolts and conical spring washers.
- 3.3.5.16 **Ground bus:** Sized per NFPA70 and UL 891 Tables 25.1 and 25.2 and shall extend the entire length of the switchboard. Provisions for the addition of future sections shall be provided.
- 3.3.5.17 **Accessibility:** Accessible from the front and rear of the switchboard.
- a. Incoming main section devices
- 1) Main circuit breaker, 2000A continuous, insulated case. Interrupting and short time rating to be a minimum of 25,000 amperes symmetrical. Provide current sensors and rating plugs to obtain the trip rating indicated on sketch SK-ALC-One Line, Appendix 7.1.
 - 2) Incoming conductors shall terminate at lug landing pads rated at 2000A.
 - 3) Electronic trip insulated case full function 100% rated circuit breaker with a minimum fault current rating of 25,000 amperes symmetrical.
 - 4) Drawout type.
 - 5) Circuit breakers shall have power terminals to accommodate either cable or bolted bus connections.
- b. Distribution section devices

- 1) Group mounted, 80% rated, thermal magnetic, molded case circuit breakers.
- 2) Circuit protective devices shall be molded case circuit breakers. Circuit breakers shall have frame and trip ratings as shown on the attached sketch SK-ALC-One Line, Appendix 7.1.
- 3) Branch circuit breakers shall be group mounted bolt-on type.
- 4) The interior shall have three flat bus bars stacked and aligned vertically with porcelain insulators laminated between phases. The porcelain insulators shall support and provide phase isolation to the entire length of bus

3.4 Interface requirements. The unit substation shall be assembled, before performing factory witnessed tests, as a complete unit to verify that each section interfaces properly with the next section.

3.5 Support requirements. Furnish the following to permit the user to safely handle and maintain the unit substation.

3.5.1 Maintainability. The design shall emphasize features to simplify maintenance actions and minimize maintenance costs, including those which facilitate easy access and preclude the need for special tools. Furnish operation and maintenance manuals as specified in paragraph 3.7.3.

3.5.2 Availability. Manufacturer's recommended spare parts lists for all equipment provided under this specification.

3.5.3 Reliability. Catalog cuts, and/or data sheets that give descriptions, dimensions, and ratings for all specified equipment. The data shall be submitted for approval by the Contracting Officer as specified in paragraph 3.7.

3.5.4 Safety. Operating safety precautions and instructions.

3.6 Verification.

3.6.1 One or more Government representatives will witness all tests, demonstrations, and inspections on the unit substation; and one representative will sign and date each requirement as it is met. The

manufacturers' standard tests on all other equipment will suffice and will not require witness testing.

3.6.2 In the event that any requirement is not met, re-verification shall be required.

3.7 Submittals.

3.7.1 Submittal procedures

3.7.1.1 **Coordination.** Coordinate the preparation and processing of submittals with the performance of the work. Coordinate each submittal with other submittals and related activities, such as testing, purchasing, fabrication, and delivery, that require sequential activity.

3.7.1.2 **Listing.** At the end of this section is a summarized listing of the submittals required for the work. The listing is included for the convenience of users of the contract documents.

3.7.1.3 **Transmittal timing.** Prepare and transmit each submittal to the Contracting Officer sufficiently in advance of the scheduled performance of related work and other applicable activities. Transmit different kinds of submittals for the same unit of work so that processing will not be delayed by the Government's need to review submittals concurrently for coordination.

3.7.1.4 **Review time.** Allow sufficient time so that contract performance will not be delayed as a result of the time required to properly process submittals, including time for resubmittals, if necessary. Allow 10 working days for initial Government processing of each submittal. No extension of time will be authorized because of the contractor's failure to transmit submittals to the Government sufficiently in advance of the work.

3.7.1.5 **"Approval" submittals.** Submittals requiring approval by the Contracting Officer are so designated in the applicable sections and the submittal list at the end of this section. When brand names or equal are specified, any "equal" submitted will require approval. Any submittal requesting a deviation will require approval. See attached submittal matrix in Appendix 7.7 that indicate which submittals require approval or are for information only.

3.7.2 **Specific submittal requirements.** Submittal requirements for individual units of work are specified below. Except as otherwise indicated in the

individual sections, comply with the following requirements for each type of submittal.

3.7.2.1 Unit substation: Furnish the following data for the unit substation:

- a. Factory test reports. Within 30 days of completion of factory testing, furnish for information five copies of the factory test data.
- b. Drawings. Within 90 days of contract award, furnish for approval certified shop drawings indicating manufacturer's engineering specifications, time/current characteristic trip curves, detailed installation information with dimensions, assembly instructions, weight, and connection details. Generic drawings are not acceptable unless they are revised to show only the equipment being furnished. The format of drawings furnished shall be: five hard commercial quality copies and one copy in electronic format (AutoCAD Release 14) on compact disk. All drawings furnished shall become the property of AEDC. The following drawings shall be considered a minimum requirement.
 - 1). Arrangement.
 - 2) Dimensional plan and elevation, front view, and other elevation views, if pertinent.
 - 3) Conduit entrance locations and dimensions for all entrances.
 - 4) Device schedules.
 - 5) One-line diagrams.
 - a) Instrument transformers.
 - b) Relays.
 - c) Meters and meter switches.
 - d) Other pertinent devices.
 - 6) Three-line diagrams.

- a). Instrument transformers.
- b) Relays.
- c) Meters and meter switches.
- d) Other pertinent devices.

7) Elementary diagrams.

- a) Furnish elementary (schematic) diagrams for the breaker control scheme and the transformer fan control circuit, drawn to ANSI standards.
- b) Each elementary diagram shall show all control devices and device contacts, each of which shall be labeled with its proper ANSI device function number.

8) Detailed connection (wiring) diagrams showing:

- a) All wiring within each unit.
- b) All interconnecting wiring between units.
- c) Identification of all terminals and terminal blocks.
- d) Transformer fan control circuit.
- e) Clear identification, by some distinguishing method, of all wiring. This shall include spare auxiliary contacts and relay contacts which shall be wired to terminal blocks for future use. Tabular wiring diagrams are not acceptable. Wiring diagrams as well as wire markers shall use a destination address identification system.

- c. Factory testing. Test plan, for approval 14 days prior to factory testing, outlining dates and tests to be performed in the presence of the Government representative.

3.7.2.2 **Switchboards.** Within 90 days of contact award, furnish for approval the following data for the switchboards:

- a. Drawings. Certified shop drawings indicating manufacturer's engineering specifications, time/current characteristic trip

curves, detailed installation information with dimensions, assembly instructions, weight, and connection details. Generic drawings are not acceptable unless they are revised to show only the equipment being furnished. The format of drawings furnished shall be: three hard commercial quality copies and one copy in electronic format (AutoCAD Release 14) on compact disk. All drawings furnished shall become the property of AEDC. The following shall be considered a minimum requirement. Five sets of engineering drawings showing:

- 1) Arrangement.
- 2) Dimensional plan and elevation, front view, and other elevation views, if pertinent.
- 3) Conduit entrance locations and dimensions for all entrances.
- 4) Device schedules.
- 5) One-line diagrams.
- 6) Three-line diagrams.
- 7) Elementary diagrams.
 - a) Furnish elementary (schematic) diagrams for the breaker control drawn to ANSI standards.
 - b) Each elementary diagram shall show all control devices and device contacts, each of which shall be labeled with its proper ANSI device function number.
- 8) Detailed connection (wiring) diagrams showing:
 - a) All wiring within each unit.
 - b) All interconnecting wiring between units.
 - c) Identification of all terminals and terminal blocks.
 - d) Clear identification, by some distinguishing method, of all wiring. This shall include spare auxiliary contacts and relay contacts which shall be wired to

terminal blocks for future use. Tabular wiring diagrams are not acceptable. Wiring diagrams as well as wire markers shall use a destination address identification system.

3.7.2.3 **General purpose transformer:** Within 90 days of contract award, furnish for approval the following data for the General purpose transformer:

- a. Drawings. Catalog cuts and/or data sheets that give descriptions, dimensions, and ratings for equipment.

3.7.3 **Operation and maintenance manuals.** Within 30 days of shipment, furnish operation and maintenance manuals with instructions for setup, operation, and repairing the high-voltage switch, transformer, breakers, and the secondary switchgear, including any associated device. Furnish instructions to include unit testing procedures, recommended transformer maintenance requirements, and frequencies with mean time between maintenance of one year or greater. The format of the instruction manuals shall be three hard commercial quality copies and one electronic copy in Microsoft Word or Adobe Acrobat Reader on compact disk. All manuals and instructions furnished shall become the property of AEDC.

3.7.4 **Spare parts list.** Within 30 days of shipment, furnish manufacturer's recommended spare parts lists for all equipment furnished under this specification.

3.8 **Workmanship.** Provide workmanship in accordance with the best modern standard practice in the manufacture of high-grade equipment of the type specified.

3.9 **Compatibility.** No modification other than customary assembly shall be required after delivery. If the unit substation components do not fit together when assembled as a complete unit, it is the contractor's responsibility to make all modifications required to facilitate the assembly of the equipment. Furnish all fasteners, electrical connectors, bus extensions, and any other hardware required for field assembly. Conform to maximum allowable dimensions for the unit substation as shown on Sketch SK-ALC-US Plan, Appendix 7.3.

4. **QUALITY ASSURANCE PROVISIONS:**

4.1 **Unit substation.** The components of the unit substation shall be tested with the manufacturer's routine factory tests and other tests as specified herein to ensure successful operation of the assemblies. All tests, demonstrations, and inspections required herein will be witnessed by the Government representative

unless waived in writing, and no equipment shall be shipped until it has been approved in writing by the Contracting Officer. Circuit breaker tests, certified by the breaker manufacturer, will be accepted in lieu of witnessed tests if the manufacturer performs the tests required by this specification. Notify the Contracting Officer at least 14 days in advance of the tests if testing is to be performed within the continental United States (CONUS). If testing is to be performed outside the CONUS, a 60-day advance notice is required. Conduct the factory tests, using test equipment, test methods, measurements, and computations, in accordance with the applicable requirements of ANSI and NEMA standards, unless otherwise specified. All tests are subject to the approval of the Contracting Officer. Conduct and report all routine tests required by the referenced standards whether specifically required by this specification or not. Clearly identify, index, and certify all test reports and test instrument calibration data and bind them into one volume. Reports of all witnessed tests shall be signed by the witnessing representatives of the contractor and the Government representative. The cost of performing the tests shall be borne by the contractor and is included in the unit price for the items of the schedule. In addition to the contractor performing the tests listed, the Government will perform acceptance tests at AEDC as listed in Section 5 prior to final acceptance. All tests shall meet the following standards.

4.1.1 Switchgear assembly tests. Subject each low-voltage circuit breakers to the production tests in accordance with ANSI C37.20.1, paragraphs 5.3 through 5.4, except as modified or supplemented as follows:

- 4.1.1.1 Check the assembled equipment for mechanical adjustment, alignment of devices mounted thereon, adequacy of fastenings and general good workmanship.
- 4.1.1.2 Perform a point-to-point check for all control, instrument, and relay wiring. Verify functional correctness of the control wiring by actual operation of the devices.
- 4.1.1.3 Subject each switchgear assembly, with all circuit breakers in operating position and contacts closed, to a dry 1-minute power frequency withstand dielectric test of 2.2 kV in conformance with ANSI C37.20.1, paragraph 5.3.1.
- 4.1.1.4 Subject all control, instrument, and relay wiring to a 1-minute power frequency withstand dielectric test of 1,000 Volts to ground in accordance with ANSI C37.20.1, paragraph 5.3.4.2.
- 4.1.1.5 Perform the production tests described in ANSI C37.50, paragraph 6, on each low-voltage power circuit breaker. Check

each circuit breaker for proper operation, and make any needed adjustments.

- 4.1.1.6 Subject each shop-assembled section of the metal-enclosed bus to a dry 1-minute power frequency withstand dielectric test between each conductor and the other conductors, and between all conductors connected together and the grounded metal housing in accordance with ANSI C37.20.1.

4.1.2 Instrument transformer tests.

- 4.1.2.1 Subject the potential and current transformers to routine tests in accordance with ANSI C57.13, paragraph 4.7.

- 4.1.2.2 Perform typical ratio and phase angle tests for each type and rating of instrument transformer.

4.1.4 Transformer tests. Perform transformer tests in accordance with ANSI C57.12.56, and C57.12.91.

- 4.1.4.1 Determine the turns ratios of the transformer windings on the rated-voltage connections and on all taps in accordance with ANSI C57.12.91. Turns ratios shall be within 0.5 percent of the calculated values.

- 4.1.4.2 Test the angular displacement and relative phase sequence on the rated-voltage connection. Check lead markings on the transformer nameplate.

- 4.1.4.3 Measure the cold and hot resistance of each winding on the rated-voltage connection and on all taps. The resistance imbalance between phases shall be less than 0.5 percent. Calculate the resistance imbalance using the following equation:

$$\text{Percent Unbalance} = \left(1 - \frac{\text{Lowest Ohmic Reading}}{\text{Highest Ohmic Reading}} \right) \times 100$$

- 4.1.4.4 Determine the transformer impedance on the rated-voltage connection at rated frequency and self-cooled rated current.

- 4.1.4.5 Perform standard temperature tests with the transformer in its enclosure. Determine the temperature rise at rated frequency at self-cooled rated kVA. The temperature rise of the transformer shall not exceed 80°C at 40°C ambient. Loading for the temperature test shall be by one of the methods described in

ANSI C57.12.91, Section 11, as proposed by the manufacturer and approved in writing by the Contracting Officer.

- 4.1.4.6 Perform standard dielectric tests, in accordance with ANSI C57.12.91 paragraph 10 corresponding to the basic impulse insulation levels of the windings as specified in paragraph 3.3.2.3 including impulse tests in accordance with paragraph 10.5.1. Make oscillograms of surge voltages during all impulse test. Make the impulse tests by direct application without 60-Hz excitation. Adjust the oscillograph to give the same deflection on reduced voltage and full-voltage impulse waves to facilitate comparison of the oscillograms.
- 4.1.4.7 Perform insulation resistance tests on all windings (2,500-V dc on the primary and 500-V dc on the secondary). Insulation resistance shall be not less than 2,000 megohms on all windings. Perform Polarization Index (PI) test on the primary winding. Minimum acceptable PI is 2.0.
- 4.1.4.8 Perform insulation power factor on the primary winding at 10-kV. The power factor test shall conform to ANSI Method II. Maximum acceptable power factor shall be 1.0 percent.
- 4.1.4.9 Measure the excitation and load losses of the transformer on the rated-voltage connection and compute the efficiencies at 100-percent power factor for 50-percent and 100-percent self-cooled rated load.
- 4.1.4.10 Measure the transformer excitation current on the rated-voltage connection at 90-percent, 100-percent, and at 110- percent rated voltage.
- 4.1.4.11 Compute and document the regulation of the transformer for self-cooled rated kVA on the rated-voltage connection at unity power factor and at 90- and 95-percent lagging power factors using appropriate data derived from the required tests.
- 4.1.4.12 Perform audible sound level measurements in accordance with ANSI C57.12.91, paragraph 13. This requirement may be waived if manufacturer's certified data for similar units are furnishd.

4.1.5 High-voltage switchgear tests.

- 4.1.5.1 High potential (hi-pot) test. Subject the shop-assembled high-voltage switch to a dry 1-minute power frequency withstand dielectric test of 36 kV between each conductor and the other conductors, and between all conductors connected together and the grounded metal housing.
 - 4.1.5.2 Contact resistance test. Measure the contact resistance of each pole across the closed switch contacts. Maximum allowable contact resistance is 50 microhms.
- 4.2 The manufacturer of the unit substation shall have a minimum of 20 years of experience building unit substations.
- 4.3 The unit substation shall be designed and assembled by a single source as multiple pieces of Underwriters Laboratories-listed equipment and coordinated to create a single product when it is installed at the job site.
- 4.4 **Other equipment.** The general purpose transformer and switchboards shall be given the manufacturer's routine factory tests and also other tests as specified herein to ensure successful operation of the assemblies.
- 5. **GOVERNMENT ACCEPTANCE TEST:** The Government will perform the following inspections and tests on the unit substation at AEDC prior to final acceptance.
 - 5.1 **Transformer.**
 - 5.1.1 Visual inspection.
 - 5.1.2 Power factor less than 1.0 percent on all windings.
 - 5.1.3 Insulation resistance not less than 2,000 megohms on all windings.
 - 5.1.4 DC resistance on all phases of each winding within 1.0 percent.
 - 5.1.5 Leakage less than 10 micro-amps at 30-kVdc on the high-voltage winding.
 - 5.1.6 Transformer turns ratio on all windings and all taps within 0.5 percent of the calculated ratio.
 - 5.2 **High-voltage switchgear.**
 - 5.2.1 Visual inspection.
 - 5.2.2 Power factor less than 1.0 percent on all phases.

5.2.3 Insulation resistance not less than 2,000 megohms on all phases.

5.2.4 Contact resistance of not more than 50-microhms on all contacts.

5.2.5 Leakage less than 50 micro-amps at 30 kV dc on all phases.

6. PREPARATION FOR DELIVERY:

6.1 The contractor shall furnish all preservation, packaging, and packing to assure safe delivery of the equipment to AEDC. Ship the equipment to AEDC as completely assembled and wired as feasible to minimize assembly work at AEDC. Carefully pack and ship separately any instrument, relay, meter, or other device which cannot withstand the hazards of shipment when mounted in place. Identify each such item so it can be readily mounted and connected. The contractor shall furnish transportation of all required items to AEDC.

7. APPENDIX:

7.1 SK-ALC-One Line, Facility 3017 – One Line Diagram.

7.2 SK-ALC-US Elevation, Unit Substation Elevation.

7.3 SK-ALC-US Plan, Unit Substation Plan View.

7.4 SK-ALC-480V SWBD #1, 480V Switchboard Elevation.

7.5 SK-ALC-480V SWBD #2, 480V Switchboard Elevation.

7.6 SK-ALC-208V SWBD, 208/120V Switchboard Elevation.

7.7 Submittal Matrix.

Submittal Matrix: This matrix consolidates the requirements for submittals. Submittal procedures and requirements are defined in paragraph 3.7.

Paragraph No.	Requirement	A	I
3.7.2.1.a	Unit Substation Factory Test Reports		X
3.7.2.1.b	Unit Substation Drawings	X	
3.7.2.1.c	Unit Substation Factory Testing Plan	X	
3.7.2.2.a	Switchboard Drawings	X	
3.7.2.3	General Purpose Transformer Catalog Data	X	
3.7.3	Operation and Maintenance Manuals		X
3.7.4	Spare Parts List		X

Approval – A
Information – I

APPENDIX 7.7 Submittal Matrix